University of North Carolina at Charlotte
College of Computing and Informatics
Department of Software and Information Systems

Course Number and Title: ITIS 6260/8260 Quantum Computing

Catalog Description: Provides students with an understanding of the fundamental concepts and algorithms of quantum mechanics, quantum computation, quantum information theory, and post quantum cryptography. Topics to be covered include quantum mechanics, quantum states, quantum entanglement, quantum measurement, qubits, quantum computation, universal quantum gates, reversible computation, quantum algorithms, quantum Fourier transform, quantum search, quantum computers, quantum noise and quantum operations, quantum error-correction, and post-quantum cryptography

Pre- or Co-requisites: Full graduate standing or permission of department.

Course Objectives:

1. To provide students with an in-depth understanding of the fundamental concepts and algorithms of quantum mechanics.
2. To equip students with a comprehensive understanding of quantum computation, quantum information theory, and post quantum cryptography.
3. To provide a wide-ranging understanding of quantum computing techniques and their impact with respect to security of current cryptographic techniques.
4. To provide students with the ability to develop simple quantum computer programs.
5. To develop the ability of students to analyze computing system security based on quantum attacks.

Course Policies: Attendance is required for all scheduled classes. One unexcused absence will cost you 5 points deduction from your final points, two unexcused absences will cost you 10 points deduction from your final points, and three or more unexcused absences may result in the failure of the course. **Late submissions receive a grade of 0**.

Instructional Method: Teaching methods may include a combination of lectures, labs, and in-class quizzes and activities. Student are expected to participate in discussions, problem solving, critical thinking exercises, analysis of case studies, group /team collaboration, and peer-teaching or lab experiences. All students are expected to contribute in a meaningful way to team efforts.

Means of student evaluation: Student evaluation will be based upon the following:

- Course midterm and final examinations. Two exams accounts for 40% of the grade.
- Two Individual and group projects. Two projects accounts for 30% of the grade
- One Research presentation. Accounts for 20% of the grade
- Other assignment. Accounts for 10% of the grade.

Specify policies that apply to this course:

1. **University Policies:**
   Code of Student Responsibility: "The *UNC Charlotte Code of Student Responsibility* (the Code) sets forth certain rights and responsibilities in matters of student discipline. The

Code defines these responsibilities and guarantees you certain rights that ensure your protection from unjust imposition of disciplinary penalties. You should familiarize yourself with the provisions and procedures of the Code" (Introductory statement from the UNC Charlotte brochure about the Code of Student Responsibility). The entire document may be found at this Internet address: **http://legal.uncc.edu/policies/ps-104.html**

2. **Academic Integrity**: All students are required to read and abide by the Code of Student Academic Integrity. Violations of the Code of Student Academic Integrity, including plagiarism, will result in disciplinary action as provided in the Code. Students are expected to submit their own work, either as individuals or contributors to a group assignment. Definitions and examples of plagiarism and other violations are set forth in the Code. The Code is available from the Dean of Students Office or online at: http://www.legal.uncc.edu/policies/ps-105.html. *Faculty may ask students to produce identification at examinations and may require students to demonstrate that graded assignments completed outside of class are their own work.*
3. **Special Needs:** UNC Charlotte is committed to access to education. If you have a disability and need academic accommodations, please provide a letter of accommodation from Disability Services early in the semester. For more information on accommodations, contact the Office of Disability Services at 704-687-0040 or visit their office in Fretwell 230.
4. **Diversity Statement:** All students and the instructor are expected to engage with each other respectfully. Unwelcome conduct directed toward another person based upon that person's actual or perceived race, actual or perceived gender, color, religion, age, national origin, ethnicity, disability, or veteran status, or for any other reason, may constitute a violation of University Policy 406, The Code of Student Responsibility. Any student suspected of engaging in such conduct will be referred to the Office of Student Conduct for possible conduct action.

   All students are required to abide by the UNC Charlotte Sexual Harassment Policy (http://www.legal.uncc.edu/policies/ps-61.html) and the policy on Responsible Use of University Computing and Electronic Communication Resources (http://www.legal.uncc.edu/policies/ps-66.html). Sexual harassment, as defined in the UNC Charlotte Sexual Harassment Policy, is prohibited, even when carried out through computers or other electronic communications systems, including course-based chat rooms or message boards.
5. **Religious Accommodation**:
   It is the obligation of students to provide faculty with reasonable notice of the dates of religious observances on which they will be absent by submitting a Request for Religious Accommodation Form to their instructor prior to the census date for enrollment for a given semester http://legal.uncc.edu/policies/ps-134.html . The census date for each semester (typically the tenth day of instruction) can be found in UNC Charlotte's Academic Calendar (http://registrar.uncc.edu/calendars/calendar.htm) .
6. **Grading Policy:**
   A = 90-100%
   B = 80 - 90%
   C = 70 - 80%

D = 60 - 70%
F = below 60

Probable textbooks or resources:

1. Nielsen, Michael A., and Isaac L. Chuang. Quantum computation and Quantum information. Cambridge University Press; 10th Anniversary ed. edition (January 31, 2011). ISBN-13: 97811070021
2. Scott Aaronson. Quantum Computing since Democritus . https://www.scottaaronson.com/democritus/
3. Wilde, Mark M. "From classical to quantum Shannon theory." arXiv preprint arXiv:1106.1445 (2011). https://arxiv.org/abs/1106.1445
4. Lecture Notes by John Preskill from Caltech: http://www.theory.caltech.edu/~preskill/ph229/#lecture
5. Richard Jozsa. Lecture Notes on QUANTUM COMPUTATION. http://www.qi.damtp.cam.ac.uk/sites/default/files/QCLectures_1to10.pdf

Topical outline of course content:

1. A layman's guide to Quantum mechanics and quantum states
2. Quantum entanglement and quantum measurement
3. Qubits, quantum computation, reversible computation, and universal quantum gates
4. Quantum noise, quantum operations, and quantum error-correction
5. Quantum computer (AQC-based and Q-circuit based)
6. Quantum algorithms and quantum Fourier transform
7. Quantum communication
8. Quantum simulation
9. Peter Shor's algorithm
10. Grover's algorithm and quantum search
11. Programming AQC (or D-wave)
12. Programming Q-circuits (project based)
13. Quantum-cryptography